HIGHWAY DESIGN	Chapter INTERSECTIONS Subject General Design Considerations And Objectives

***Summary*:** By definition, an intersection is the area in which two or more highways join or cross. This includes the roadway and the appurtenances associated with the intersecting roadways. Intersection design is a key component in the design of a highway system and can affect the efficiency, safety, speed, operating costs and capacity of the roadway system.

There are three general types of intersections: (1) At-Grade Intersections, (2) Grade Separations without Ramps, and (3) Interchanges.

The main goal of intersection design is to facilitate the safety, convenience, ease and comfort of the highway user traversing the intersection, while enhancing the safe and efficient movement of various vehicles and pedestrians.

Four basic elements should be considered in intersection design:

- Human Factors
- Traffic Movement Considerations
- Physical Elements
- Economic Factors

HUMAN FACTORS: Human factors affecting intersection design include driving habits, the driver's ability to make decisions and their expectancy, and decision and reaction time. Pedestrian and bicycle use also affect intersection design.

TRAFFIC CONSIDERATIONS: Traffic issues to take into consideration include design and capacities, turning movements, variety of movements, vehicle speeds, pedestrian and bicycle movements.

PHYSICAL ELEMENTS: There are several physical elements that also affect intersection design. The character and use of the adjoining property, vertical alignments of the intersecting roadways, sight distance, and the angle of the intersection are important issues. The conflict area, traffic control devices, lighting equipment, environmental factors, and crosswalks are just a few of the other considerations.

ECONOMIC FACTORS: The cost of intersection improvements should be considered as well as the effects of controlling or limiting rights-of-way on adjoining commercial and residential properties.

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HIGHWAY DESIGN	Chapter INTERSECTIONS Subject At-Grade Intersections

***Summary*:** The basic intersection configurations are the three-leg "T", the four-leg, and the multi-leg. At each specific location, the intersection type is determined by the number of intersecting legs, the topography of the area, the character of the intersecting highways, traffic volumes and movements, speeds and desired type of operation.

Horizontal and vertical alignment, cross-sectional elements, adequate sight distance and drainage issues are very important design elements in the layout of an at-grade intersection. These features contribute a great deal to the overall operation of the facility.

HORIZONTAL AND VERTICAL ALIGNMENT:

The horizontal alignment and vertical grades of an intersection should be designed to permit users to visually recognize the intersection, the other vehicles using it, and to readily perform the needed maneuvers to pass through the intersection safely. Generally the alignments should be as straight and the gradients as flat as feasible. Major grade changes should be avoided at intersections and adequate sight distance should be provided along both intersecting roads. Ideally grades exceeding 3 percent on the major road(s) should be avoided in the vicinity of the intersection. Where this is not feasible, grades greater than 6 percent should be avoided.

The designer/project team should review each intersection thoroughly and determine an acceptable solution. When designing an intersection, the mainline grades/cross-slopes generally are carried through the intersection and the approach roadways adjusted to match the mainline geometrics. However, there are times when intersection design may be controlled by constraints other than the crossing roadway geometry. The design may need to address such intersection characteristics as traffic volumes, type of design vehicles, design speed, functional characteristics, type of intersection control, and the topographic constraints of the location.

Each intersection should be adjusted at all intersecting legs, as necessary, to accommodate adequate sight distance requirements, driver comfort during maneuvers and any drainage concerns. This might be accomplished by modification of the mainline/approach grade points, cross-slopes, etc. The goals for an intersection should include: smooth and continuous intersection elements, smooth transitions for vehicles changing directions, grades as level as practical, and sufficient sight distance to allow drivers to prepare for and avoid potential conflicts.

For safety and economic reasons, the intersecting roadways should meet at right angles when feasible. Although a 90-degree intersection is desired, some deviation from this is permissible. Generally intersection angles between 75 and 90-degrees are preferred. Intersection angles of at least 70-degrees should be provided.

TURNING ROADWAY ELEMENTS:

Turning roadways are created by high-type right-turn radius designs and corner traffic islands. They are typically used at high-speed and/or high volume intersections, and are associated with a high level of service for right-turn vehicles. It is important to provide a turning roadway design that is consistent with the speed and volume characteristics of the turn. The primary design elements of a turning roadway are 1) radius of turn, 2) development of superelevation, and 3) width of roadway.

The relationships between speed and curvature may be found on the exhibit titled “Minimum Radii for Intersection Curves” found in Chapter 3 of AASHTO’s ***A Policy on Geometric Design of Highways and Streets***, current edition. Kentucky’s common practice is to use a maximum superelevation of 8%. Note that the minimum radii indicated in this exhibit should be used as the inner edge of pavement for the turning roadway.

Three-centered compound curves may also be considered as an option when determining an intersection radius. Three-centered compound curves information may be found in the exhibit titled “Typical Design for Turning Roadways” found in Chapter 9 of AASHTO’s ***A Policy on Geometric Design of Highways and Streets***, current edition.

The turning path of the design vehicle and angle of turn determines the widths of turning roadways. Chapter 2 of AASHTO’s ***A Policy on Geometric Design of Highways and Streets***, current edition, details the various types of design vehicles with their dimensions and turning radii. Chapter 9 of AASHTO’s ***A Policy on Geometric Design of Highways and Streets***, current edition, summarizes the minimum edge of traveled way values for various vehicles and turning angles.

ROUNDABOUTS

Roundabouts are a common form of intersection control used throughout the world to improve the safety and traffic flow conditions. For detailed discussions concerning roundabouts, please refer to ***AASHTO's Policy on Geometric Design of Highways and Streets***, current edition and various publications such as the Federal Highway Administration ***Roundabouts: An Informational Guide***.

On a case-by-case basis, the Kentucky Transportation Cabinet will consider roundabout use. Once the Project Team has determined that a roundabout facility could be an option, the Department or Consultant shall perform a detailed analysis, including geometric layouts, cost estimates, and capacity of the proposed facility. Other types of intersection facilities shall also be evaluated and compared with the roundabout analysis. This analysis shall be included in the Design Executive Summary.

ISLANDS AND CHANNELIZATION:

An island is defined as the area between traffic lanes that is used to control vehicle movements (channelization/division of traffic), provide a pedestrian refuge area, a place for traffic control devices, and/or contribute to aesthetics. Within an intersection, a median is also considered to be an island.

Channelizing islands are used at certain intersections to control and direct traffic movements into the proper paths. If an intersection area is spacious, a channelizing island might be utilized to decrease the confusion of the traffic movements. Channelizing islands may be of many shapes and sizes. A common form is the corner triangular shape that separates right-turning movements. Central islands may serve as a separation for turning vehicles to operate around.

Divisional islands are often included on undivided highways at intersections. They alert and regulate traffic through the intersection. They might control the location of left-turning vehicles.

Refuge islands are predominately utilized in urban areas where there are a lot of pedestrian and/or bicycle movements across an intersection. They aid and protect pedestrians and/or bicyclists that cross the roadway. Generally, any of the above mentioned island types could also serve as a refuge island.

The dimensions and details of an island depend on each individual intersection configuration. They should be of significant size to command attention. Islands can be delineated or outlined by a variety of treatments, depending on their size, location, and function. The type of facility (rural versus urban) in which the intersection is located will also control the island design.

Normally flush islands should be used in intersections with large turning radii. Exceptions may be made in instances where the island is large and may be utilized to shield pedestrians or where special signing or poles may be placed in the island. The Project Team may decide to utilize a raised island in this case. If a raised island is utilized, it should be designed as a mountable island where practical. Barrier curb may be utilized for a traffic island where the Project Team deems conditions warrant.

Interchanges represent special design considerations. An inherent problem of interchanges is the possibility of a driver entering one of the exit terminals from the crossroad and proceeding along the major highway in the wrong direction in spite of signing. Islands provide a means of channelizing the traffic into proper paths and can be effectively used for sign placement. The intersection on the crossroad formed by the terminals function as any other “T” intersection at-grade and should be designed accordingly (See AASHTO’s Policy on Geometric Design, Chapter 9 and 10 for details). However, because these intersections have four legs, two of which are one-way, they present a problem in traffic control to prevent wrong-way entry from the crossroad. For this reason, the project team should strongly consider providing a median on the crossroad to facilitate proper channelization. While this median can be a painted median, the project team should also consider the use of a depressed or raised median with sloping curb where conditions are deemed appropriate.

Where practical, large islands should be depressed to avoid water and snow melt draining across the pavement. Please refer to Chapter 9 of AASHTO’s ***Policy on Geometric Design of Highways and Streets***, current edition, and Chapter HD-702 of the Design Manual for a detailed discussion.

SUPERELEVATION:

The superelevation rates for the through roadway at an intersection should comply with the appropriate values obtained from the tables in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets***, current edition. When traffic control devices are anticipated on any leg of the intersection, the designer may elect to modify the superelevation rates through the intersection area to achieve an acceptable design. The designer must first consider the: (a) vehicle's ability to stop and accelerate during periods of ice and snow, (b) right-of-way damages, (c) grade on existing street approaches and entrances, and (d) drainage. The desirable maximum superelevation for horizontal curves through intersections is 4%.

Exhibit 10-01 shows a procedure to reduce the sharp breaks in the profile of roads crossing a roadway with a depressed median. It depicts how adjustment of the grade points on the roadway having the depressed median can reduce the severity of the breaks at the inside edges of pavement. The decision to use this or similar procedure should be on an intersection by intersection basis.

Superelevated areas adjacent to a through lane having a normal crown or a different superelevation results in a "cross-over line" which can cause a hazardous pitch or sway in a vehicle. An example where this occurs is a turning roadway (i.e. off ramps) adjacent to a through roadway.

When introducing or removing superelevation rates, refer to Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets***, current edition.

TRAFFIC CONTROL DEVICES:

Traffic control devices regulate, inform, warn, and guide drivers. Items utilized for this include signals, lighting, signing, arrow panels, changeable message signs, etc. The decision to utilize traffic control devices and their configuration should be discussed and decided by the Project Team on an intersection-by-intersection basis.

The Project Manager is ultimately responsible for making sure the appropriate traffic plans are identified and included in the total plan set. In order to facilitate this process, the Project Manager should notify the District Traffic Engineer of project team meetings and inspections as early in the process as feasible.

When the project team identifies locations that might require signal, signing, and/or lighting plans, the District Traffic Engineer should notify Central Office Traffic in writing and provide appropriate supporting information.

SIGHT DISTANCE: Sight distance at intersections is provided to allow drivers approaching the intersection to recognize the potential of conflicting vehicles that may also be approaching the intersection. This includes drivers that are stopped on an approach road by giving them enough view to decide whether or not to turn onto or cross the roadway.

When determining if an object/structure is obstructing sight distance at an intersection, the designer should consider both horizontal and vertical alignment information for both intersecting roadways. Assume that the drivers eye height is 3.5 ft. above the roadway and that the object height is also 3.5 ft. above the surface of the roadway. Using 3.5 ft, for both the drivers eye and object height ensures that if the driver of one vehicle can see the other vehicle, then the other vehicle driver can see the first vehicle as well.

The minimum stopping sight distance at any point within an intersection shall be consistent with the design speed at that point. See Common Geometric Practice sheets for appropriate roadway type.

The recommended dimensions of the sight triangles vary with the type of traffic control used at an intersection because different types of control impose different legal constraints on drivers and, therefore, result in different driver behaviors. Procedures to determine sight distances at intersections are presented in Chapter 9 of AASHTO's ***A Policy on Geometric Design of Highways and Streets***, current edition.

At intersections where cross traffic is controlled by a stop sign, additional stopping sight distance must be provided for the vehicles on the major highway due to the possibility of conflicts between vehicles on the through road and the cross road.

The desired intersection sight distance is a function of the following:

- The type of control,
- The type of the design vehicle,
- The acceleration rate of the design vehicle,
- Perception and reaction time,
- The width of pavement and in cases of divided highways the width of the median,
- Design speeds,
- Skew angle of intersection and gradient of roadways.

AASHTO's *A Policy on Geometric Design of Highways and Streets,* current edition, contains a thorough discussion of intersection sight distance with accompanying tables and charts. Consult this publication for guidance.

MEDIAN OPENINGS (CROSSOVERS):

Median openings are breaks in the median to allow traffic to cross. These openings facilitate traffic movement and access management. Spacing of the openings should be consistent with the type of access control along the roadway. Median openings should be situated where there is adequate sight distance.

The design of a median opening and the shape of the median ends should be based on traffic volumes, urban/rural characteristics, and types of turning vehicles. The median width, location and length of opening, and the design of the median-end shape are developed in combination to fit the character and volume of both through and turning traffic.

For three-or four-leg intersections on a divided highway, the length of median opening should be as great as the width of the crossroad travel way plus shoulders. Where the crossroad is a divided highway, the length of the opening should be at least equal to the width of crossroad traveled way plus median width of crossroad.

There are two common shapes utilized at the ends of a median:

- Semicircle, which is satisfactory for narrow medians, and
- Bullet Nose Designs, which closely fit the path of the inner wheel of the design vehicle. This is the preferred shape at approach intersections. For median widths 10' or greater, the bullet nose design should be used in the design.

Refer to Chapter 9 of **AASHTO's *A Policy on Geometric Design of Highways and Streets***, current edition, for specific details of median opening shapes.

AUXILIARY LANES:

An auxiliary lane is defined as the section of the roadway, adjacent to the through lanes, utilized for speed changes, left and right turning movements and storage, weaving maneuvers, truck climbing lanes and other various purposes. Auxiliary lanes may also be added to improve the safety and the capacity of an intersection.

Many factors should be considered by the designer when analyzing the need for an auxiliary lane, such as, speeds, traffic volumes (including opposing volumes), percentage of trucks, capacity analysis, type of facility, location (rural/urban), etc.

The most common types of auxiliary lanes are left and right turning lanes. These lanes are made up of three components: (1) bay taper, (2) deceleration length, and (3) storage length.

Left-turn lanes:

The following are general guidelines for the use of left-turn lanes:

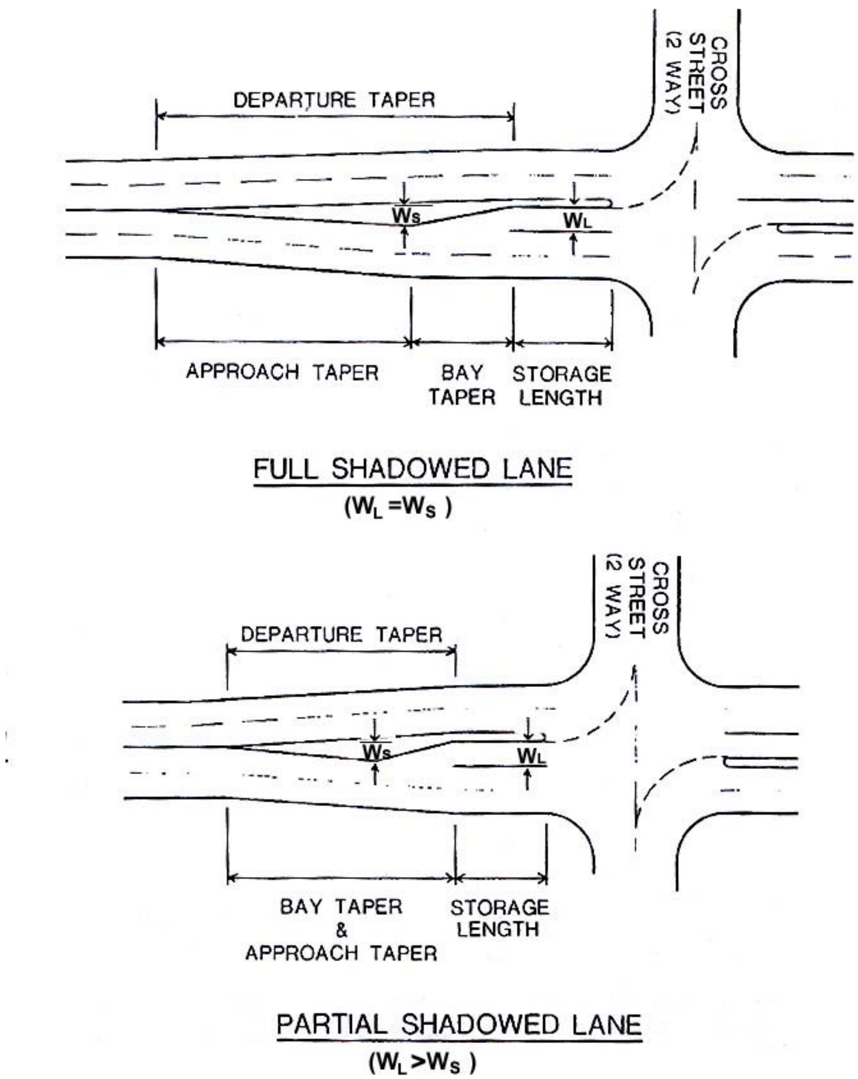
Signalized Intersection

- Consider left-turn lanes at all new signalized intersections with analysis of capacity and phasing to accommodate left turns.
- Left-turn lanes are required if the left-turn volume exceeds 20 percent of the total advancing volume or 100 vehicles during the peak hour.
- Consideration should also be given to the volume of traffic opposing the left-turn movement. See the exhibit "Guide for Left-Turn Lanes on Two-Lane Highways" in Chapter 9 of **AASHTO's *A Policy on Geometric Design of Highways and Streets***, current edition.

Unsignalized Intersection

- Left-turn lanes should be provided at median openings on divided roadways. (This does not apply to the median crossovers on freeways and Interstates.)
- Consider left-turn lanes where sight distance is limited.
- Left-turn lanes should be provided at all non-stopping approaches of rural arterials and collectors.
- Left-turn lanes should be provided on all other approaches where required based on capacity, safety, and operational analysis.

Double left-turn lanes may be utilized at any signalized intersection with high design hour demand for left-turns. A capacity analysis should be used to determine when to utilize double left-turn. As a general "rule-of-thumb," when left-turn volumes exceed 300 vehicles per hour, provision of multiple left-turn lanes should be considered.



Elements of Left turn channelization

When adding a left-turn lane, an approach taper is used to widen the pavement to the required width. The approach taper should be as follows:

SPEED: 45 mph or greater, Taper Length $L = W \times S$

40 mph or less, Taper Length $L = \frac{WS^2}{60}$

where

L = Taper Length in feet
W = Width of roadway offset for taper in feet
S = Speed in miles per hour

Bay tapers are utilized to direct turning vehicles into the auxiliary lane. For left-turn lanes, it is recommended to use bay taper rates between 8:1 and 15:1.

On low speed streets, or in areas with limited space, the bay and approach tapers can be combined. The total taper produces a partially shadowed left-turn lane, as illustrated above. With the partially shadowed left-turn lanes, the offset created by the approach taper does not entirely project or "shadow" the turn lane.

The length of a left-turn lane is based on the deceleration requirements, storage requirements, or a combination of both. Based on AASHTO criteria, the deceleration length ranges from 235 feet for 30 mph to 435 feet for 50 mph. (For more deceleration length values, see the exhibit titled "Deceleration Distances for Passenger Vehicles Approaching Intersections" in Chapter 2 of **AASHTO's *A Policy on Geometric Design of Highways and Streets,*** current edition.) Adding the deceleration distance to the storage length can result in a longer left-turn lane that may entice drivers into the lane not realizing it is a left-turn lane. Common practice is to accept a moderate amount of deceleration within the through lanes and to consider the bay taper as a part of the deceleration length. Where intersections occur as much as four per mile it is customary to forgo most of the deceleration length and to provide only the storage length plus bay taper. It is more important to provide adequate storage length to avoid blocking the through traffic lanes. The AASHTO guidelines for storage length are as follows:

1. Unsignalized intersection – the storage length, exclusive of tapers, may be based on the average number of left-turning vehicles likely to arrive in a 2-minute period of the peak hour. When conditions warrant, a minimum storage length should be provided for 2 passenger cars or, when there is 10% or greater truck/bus traffic, the minimum length should be one car and one truck/bus. A storage length of 25 feet per passenger car and 75 feet per truck/bus is assumed.

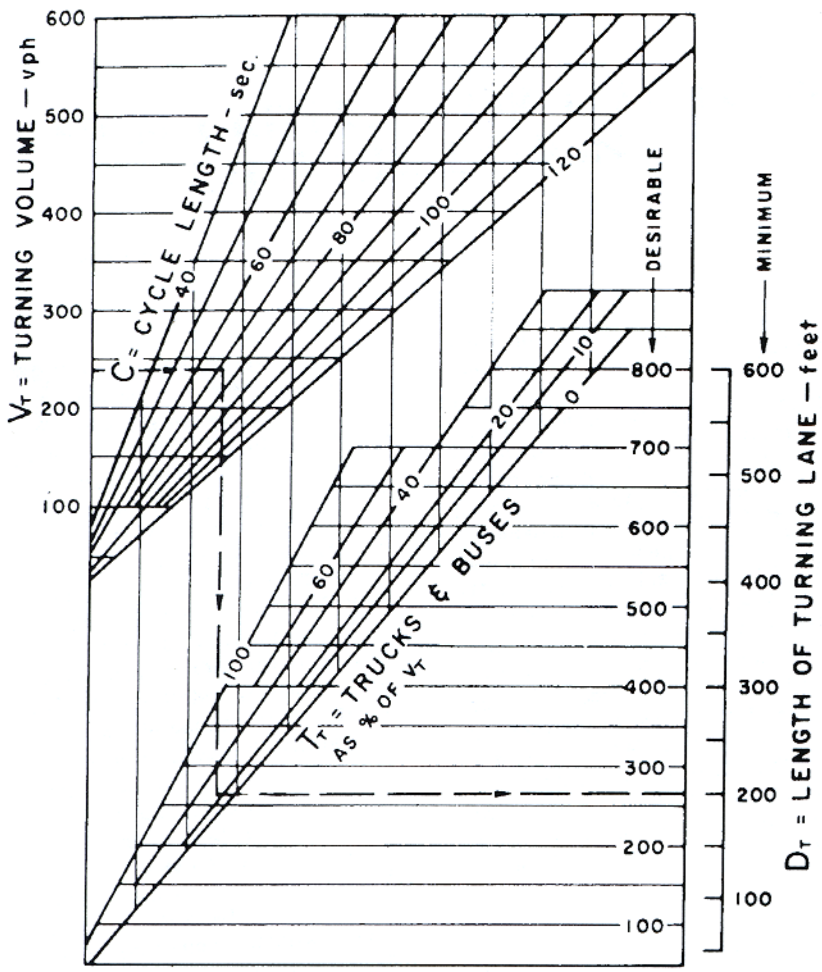
2. Signalized intersection – the storage length, exclusive of tapers, should usually be based on 1 ½ to 2 times the average number of vehicles that would arrive during an average cycle length in the design hour. A nomograph for estimating storage length at signalized intersections is provided below.

The example shown on the nomograph is as follows:

Conditions: 240 vph left-turn
72 second cycle
10% trucks

Solutions: Minimum Storage = 200 ft.
Desirable Storage = 260 ft.

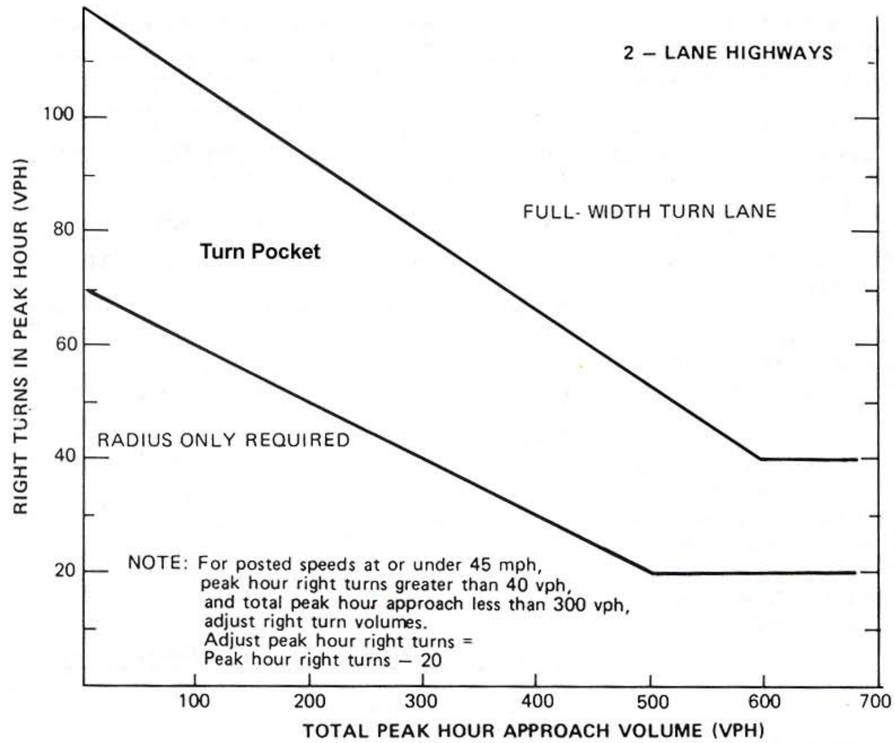
Nomograph: Storage for a Single Turn Lane
at a Signalized Intersection

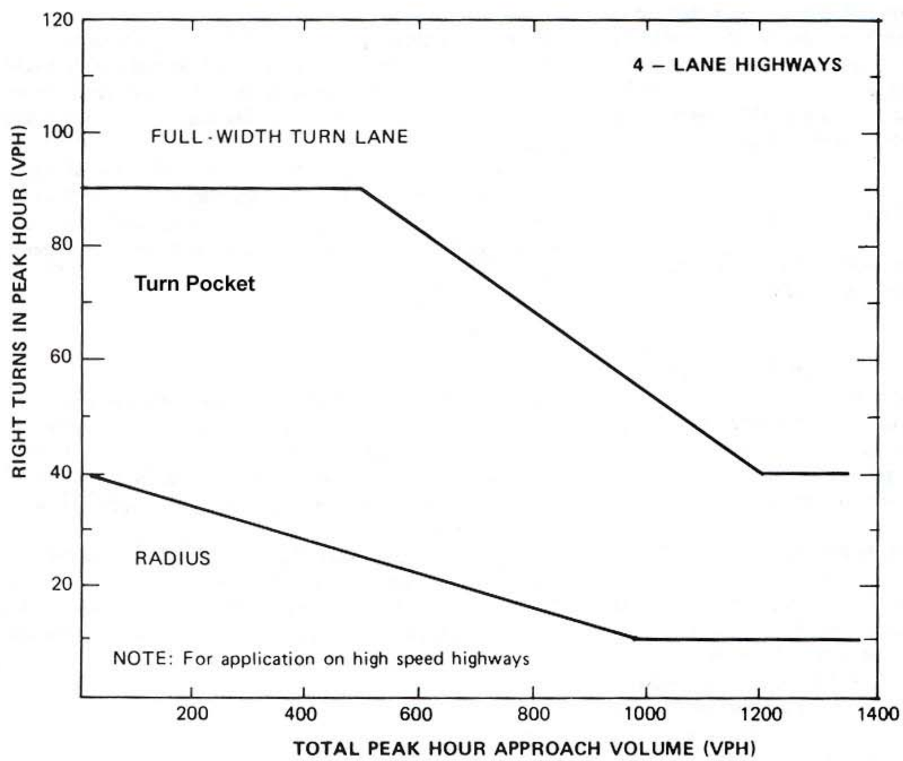


The departure taper should begin opposite the beginning of the full-width left-turn lane, and should extend to the beginning of the approach taper.

Right-Turn Treatments:

There are three treatments that can be utilized to enhance the right turning movements at an intersection: a corner radius, right-turn pocket, and right turn lane. The graph below provides traffic volume guidelines for the design of right-turn treatments.





Traffic volume guidelines for design of right-turn lanes.

Corner Radii Design: Adequate corner radii for vehicle movements must balance the needs of the vehicle, the pedestrian or bicycle traffic, and the ability to acquire the necessary right-of-way. Ideally, corner radii on high-speed approaches should be designed to accommodate moderate to high-speed right turns when pedestrian/bicycle movements are not present. Low-speed right turns are desirable at intersections with heavy pedestrian/bicycle traffic, such as in dense urban areas. For corner radii design, multi-centered curves and circular curves with tangent offsets are useful alternatives to simple circular curve designs. Refer to Chapters 2,3 and 9 of AASHTO's ***A Policy on Geometric Design of Highways and Streets***, current edition, for more details and exhibits.

Right-turn Pocket: A right-turn pocket may be used at any minor intersection not requiring a deceleration lane. A right-turn pocket consists of an 8:1 bay taper with 50-foot storage for rural areas and 100-foot storage in urban areas. The shoulder width may be reduced in the area adjacent to the right-turn pocket to a minimum width of 4 feet.

Right-turn lane: Although right-turns usually involve fewer and less severe conflicts, and tend to have less influence on the through traffic movements at intersections, there are times that the added cost of providing a right-turn lane is justified by the improvements to the traffic flow.

In addition to the above "Guidelines for Design of Right-Turn Treatments," the Project Team should consider the following items when determining the need for right-turn lanes at an intersection:

- In urban areas – the amount of approach volume turning right; presence of pedestrians and bicycles that would conflict with the right-turning vehicles; and severe skew or grade that increases the difficulty of right turns.
- In rural areas and on high-speed suburban-type facilities – solution for the reduction of potential rear-end collisions and high volumes of right-turns generated by adjacent land use.
- Exclusive right-turn lanes should be considered when the right-turn volume exceeds 300 vph and the adjacent through lane volume exceeds 300 vph for the design hour.
- The full shoulder width adjacent to the right-turn lane can be reduced to a minimum width of four feet.

The design of a right-turn lane is similar to that of a left-turn lane. A right-turn lane consists of a bay taper, deceleration length and/or storage length. As with left-turn lanes, it is acceptable to include the taper as part of the deceleration length. Also, where intersections occur as much as four per mile it is customary to forgo most of the deceleration length and to provide only the storage length plus bay taper.

For right-turn lanes, it is recommended to use bay taper rates between 8:1 and 15:1.

For deceleration length, please refer to the following chart for acceptable deceleration lengths.

Design Values for Length of Deceleration For Design Speed of Corner Radius (mph)			
Highway Design Speed (mph)	Stop Condition (assumes right-turn lane on approaches to stop signs and traffic signals)	15 mph (assumes use of 50 foot Corner Radius)	20 mph (assumes use of 90 foot Corner Radius)
30	235	185	160
40	315	295	265
50	435	405	385
60	530	500	490
65	570	540	530
70	615	590	570

When determining storage length for a right-turn lane, use the same guidelines as used for the left-turn lane storage length.

AASHTO's *A Policy on Geometric Design of Highways and Streets,* current edition, contains a discussion of auxiliary lanes. Consult this publication for guidance. Also, **NCHRP Synthesis 225,TRB, "**Left-Turn Treatments at Intersections" and **NCHRP Report 279, TRB, "**Intersection Channelization Design Guide" are useful resources that can be consulted when assessing the need and geometrics of an auxiliary lane. The ***Highway Capacity Manual***, current edition, should be consulted when analyzing the intersection capacity.

DRIVEWAYS/ ENTRANCES: Ideally, do not locate driveways/entrances within the functional area of an intersection, which would include the limits of any auxiliary lanes being utilized.

As with other types of intersections, driveways/entrances should intersect the roadway at a 90-degree angle whenever feasible. Refer to KYTC Standard Drawings RPM-110, RPM-150 and RPM-152 current edition for details. Also Chapters 4 and 9 of **AASHTO's *A Policy on Geometric Design of Highways and Streets,*** current edition, contains further discussions concerning driveways.

PEDESTRIANS AND BICYCLES: The Department must promote the safe and efficient movement of both vehicles and pedestrians, and each intersection must receive consideration based on conditions that exist at the individual location. Considerations should include (1) the vehicular flow, including percentage and types of trucks, (2) pedestrian movement (i.e., heavy, moderate, light), (3) the presence of pedestrian generators (i.e., schools, malls, etc.), and (4) the Project Team's recommendation. When intersection conditions indicate heavy traffic volumes and negligible pedestrian movements, the designer may use enlarged radii, including free flow movement on right turn lanes. If a decision is made to allow free flowing movements, consideration should be given to encourage pedestrian movements in other locations outside the intersection area. See the Cabinet's ***Pedestrian & Bicycle Travel Policy*** for more information.

In areas where sidewalk is utilized, the facility is to comply with the Americans with Disabilities Act (ADA). Sidewalk Ramp Types and Details are shown in KYDOT Standard Drawings RPM-160 through RPM-172, current edition. The ***Manual of Uniform Traffic Control Devices***, current edition, should also be consulted for details of intersection striping and signing for pedestrian traffic.

Bicycles, unlike pedestrian transportation, can safely share the roadways with motor vehicles when appropriate consideration is made during the design and construction of new or reconstructed roadways. When bicycle lanes are provided at an intersection, please refer to Cabinet's ***Pedestrian & Bicycle Travel Policy*** and this manual's chapter on Additional Highway Design Topics for a detailed discussion.

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HIGHWAY DESIGN	Chapter INTERSECTIONS Subject Grade-Separation Without Ramps

Summary: Grade-separation facilities provide for the safest, most efficient movement of vehicles, pedestrians and/or bicycles across intersecting roadways. Conflict points between the facilities are eliminated when one of the roadways is either taken over or under the other facility, depending on the terrain of the project area. The ability to use this type facility is usually based upon the type of terrain, the type of facility being constructed, the type of access control being utilized on the facility and economic considerations.

There is no minimum spacing along a corridor or limit to the number of grade-separated facilities along a roadway.

VERTICAL CLEARANCE: In selecting the alignment and grades of intersecting roadways, a major control is vertical clearance under overpasses. For various types of roadways, the following minimum vertical clearances apply:

TYPE OF ROADWAY	MINIMUM CLEARANCE* (Feet)	DESIRABLE CLEARANCE (Feet)
Interstate, federal aid primary in rural areas	16.5	17.5
Strategic Highway Network	16.5	17.0 - 17.5
All others	14.5	17.0 - 17.5

*For rehabilitation/reconstruction work involving existing bridges, vertical clearance can be reduced by 0.5 feet from above minimum clearances.

The Strategic Highway Network (STRAHNET) is all rural Interstates and selected urban Interstates. In Kentucky, the selected urban Interstates are the following:

Louisville - I-65, I-71, I-264 from I-64 to I-71
Covington - I-75 north to I-275 east, I-275 east to I-75 north in Ohio

The above chart applies to both Grade-Separation and Interchange Facilities. The minimum clearances are required across the entire roadway width, including the usable shoulder.

Where practicable, the desirable clearance under bridges on the interstate should be used to accommodate future overlays.

HORIZONTAL CLEARANCE: Minimum horizontal clearances vary, depending upon the functional classification of the roadways. The designer shall consult the ***Division of Bridge Design Guidance Manual*** for specific details and design criteria. Horizontal clearance and clear zones are not interchangeable. For clear zones, see the AASHTO ***Roadside Design Guide,*** current edition.

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Summary: According to AASHTO, the definition of an interchange is "a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels".

DESIGN CONSIDERATIONS:

Once it is determined that an interchange is going to be utilized (based upon highway classification, traffic types and movements, design speeds, access control type, economics, etc.) alternate configurations should be studied and discussed at the Project Team Meetings. Generally, minor roadways should pass over major roadways. This configuration takes advantage of off-ramp traffic being able to decelerate on the upgrade and the on-ramp traffic being able to accelerate on the downgrade.

Every interchange is unique. The Project Team should take great care in deciding the most appropriate interchange configuration, based upon (but not limited to) the following:

- Route Continuity/Lane Balance,
- Capacity of Interchange,
- Uniform/Consistent Exit Patterns,
- Weaving Considerations,
- Cost,
- Impacts to Surrounding Properties,
- Environmental Considerations, and
- Maintenance of Traffic issues.

A general guideline for minimum spacing of interchanges is 1 mile in urban areas and 2 miles in rural areas. For design standards for interchanges on Interstate routes, refer to AASHTO's ***A Policy on Design Standards – Interstate System***.

HORIZONTAL AND VERTICAL ALIGNMENT: The horizontal and vertical alignments of the intersecting roadways will be controlled by the design speed and class of road for each roadway, as detailed in Chapter HD-700 of this manual and **AASHTO's *A Policy on Geometric Design of Highways and Streets,*** current edition. However, if practicable, the roadways should intersect at 90° in tangent sections with grades as flat as possible.

RAMPS:

Ramps are turning roadways that connect two or more legs at an interchange. In general, the horizontal and vertical alignments of ramps are designed based upon a lower design speed than the intersecting roadways.

Horizontal Alignment - Use 230 feet for the minimum radius at any point on a non-loop ramp, which corresponds to a 30 mph design speed. However, at the exit terminal from the major roadway, the design speed of the first curve on the ramp should desirably be 70 percent of the mainline design speed. If this is not practicable, lesser design speeds are permissible if lengthening the deceleration taper on the mainline. (See chapters 3 and 10 in **AASHTO's *A Policy on Geometric Design of Highways and Streets,*** current edition.)

When using compound curves, as in the design of loop ramps, the radius of any curve should be not less than one-half the radius of the preceding curve. To provide adequate transition for multiple compound curves, the length of arc for each curve should be as follows:

LENGTHS OF CIRCULAR ARC FOR COMPOUND CURVES ON RAMPS WHEN FOLLOWED BY A CURVE OF ONE-HALF RADIUS OR PRECEDED BY A CURVE OF DOUBLE RADIUS

	Length of circular arc (ft)	
Radius (ft)	Minimum	Desirable
100	40	60
150	50	70
200	60	90
250	80	120
300	100	140
400	120	180
500 or more	140	200

- Vertical Alignment - Ramp grades should not exceed six percent. If large volumes of trucks are present, upgrades should be limited to four percent.

Ramp Lane Widths **-** Single lane ramps shall have a minimum pavement width of 15 feet with a six-foot usable shoulder right and a 4-foot usable shoulder left. Two-lane ramps shall have a minimum pavement width of 24 feet with a 6-foot usable shoulder right and a 4-foot usable shoulder left. (Typical section examples are included in the Exhibits at the end of Chapter HD-900.)

Pavement widths can vary depending on ramp radii, traffic conditions, etc.; therefore, the designer is advised to refer to Chapter 10 in AASHTO's ***A Policy on Geometric Design of Highways and Streets,*** current edition, for additional guidance.

SUPERELEVATION:

Superelevation on the mainline, minor roadway and ramp proper shall be in accordance with Chapter HD-702 of this manual and AASHTO's ***A Policy on Geometric Design of Highways and Streets,*** current edition.

SPEED CHANGE LANES:

In order to minimize the interference with the through traffic and to decrease the accident potential, deceleration and acceleration lanes should be provided within the interchange area. These lanes are generically referred to as Speed Change Lanes.

The Speed Change Lane should be of sufficient length to allow the driver to comfortably and safely maneuver from the roadway to the ramp. There are two general types of speed-change lanes: (1) Taper and (2) Parallel.

Please refer to Chapter 10 of AASHTO's ***A Policy on Geometric Design of Highways and Streets,*** current edition, for detailed discussions, charts and drawings concerning speed-change lanes (Exhibits 10-69, 10-70, 10-71, 10-72 and 10-73).

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HIGHWAY DESIGN	Chapter INTERSECTIONS
	Subject Procedures

Summary: The basic procedures KYTC follows when designing at-grade, grade-separation and interchange facilities include the following:

Assemble Basic Data:

- **Traffic Data:** The designer should request both current year and projected design year traffic information from the Division of Multimodal Programs.

  The designer should then take the above data and perform a detailed traffic analysis based upon the guidelines presented within the ***Highway Capacity Manual***, current edition.

- **Site Data:** All appropriate topographic, planimetric (including utilities), property ownership, and environmental data information should be collected. This information is critical to the evaluation of different alternatives.

- **Crash Data:** This data should be a major consideration when re-designing an existing facility. The designer should request crash data from the Division of Traffic and any other appropriate source

Prepare Alternative Studies:

The designer should prepare studies of alternative configurations/alignments for the intersecting roadways. Some of the major items that should be considered include:

- **Proposed Horizontal and Vertical Alignment of the Intersecting Roadways** – The designer should carefully study the alignment of the intersecting facilities. Appropriate considerations include, but are not limited to:

  - Intersection angle between roadways should be between 70 and 120 degrees,
  - Horizontal/vertical curvature,

- Potential environmental, utility, and right-of-way impacts,
- Intersection sight distance,
- Capacity analysis,
- Grades,
- Stopping sight distance, and
- Determination of which facility should pass over and which facility should pass under for grade-separated roadways, along with vertical clearance requirements.

Realignment of existing facilities should be considered in order to provide quality intersection design.

- **Proposed Road Crossings with Depressed Medians** – Exhibit 900-01 shows a procedure to reduce the sharp breaks in the profile of roads crossing a roadway with a depressed median. It depicts how adjustment of the grade points on the roadway having the depressed median can reduce the severity of the breaks at the inside edges of pavement. The decision to use this or similar procedure should be on an intersection by intersection basis.

- **Channelization Details** – When at-grade intersections are utilized, the designer shall evaluate each intersection to determine the need for channelization. Any of the following conditions may warrant the channelization of an intersection:

  - High crash frequency,
  - Dense vehicular traffic,
  - High-speed vehicular traffic,
  - Complex intersection,
  - Wide roadway,
  - Pedestrian movements, and
  - Difficulty in providing adequate control by use of standard signs and markings.

- **Maintenance of Traffic During Construction** – The designer should develop a scheme for maintaining traffic movements through the intersections. Sufficiently develop this scheme to detail maintaining traffic lanes, a general sequence of construction phasing and any detours or temporary pavement widening which will be required.

- **Right-of-Way Widths** – The designer should exercise care to provide adequate right-of-way for sight distance, traffic signal supports, signing, lighting, and potential utility location.

- **Proposed Drainage** – An evaluation should be made of existing and proposed drainage systems and their potential effects on the proposed design.

- **Evaluation of Utility Impacts** – The designer should evaluate the impacts on both existing and relocated utilities within the proposed intersection. Impacts to all utility companies, both private and public, should be considered when evaluating the effect of the project on the utilities. In some cases, it may be necessary to alter the alignment and/or grade in order to avoid relocation of major utilities.

- **Pedestrian Facilities** – The Project Team will make a determination of the need for pedestrian facilities in accordance with the Cabinet's ***Pedestrian & Bicycle Travel Policy***.

- **Cost Estimates** – Prepare preliminary cost estimates for each alternative studied. The estimates should include Construction, Right-of-Way Acquisition, Utility Relocation and other significant costs.

Submitting the Alternatives to the Project Development Team:

The following information should be included with each alternate submitted to the project team.

- Plan and Profile details of the intersecting roadways,
- Traffic Analysis,
- Cost Estimates,
- Discussion of the pros/cons of each alternate, and
- Any other information that the team believes to be beneficial.

For interchanges, the Project Team shall make a recommendation to the Director of the Division of Highway design for the chosen alternative. The Director will decide the appropriate selection/approval documentation required.

When an interchange is being submitted, include an original plot of the geometric layout sheet with a block for a recommendation signature by the project manager and approval signatures by the Directors of the Division of Design and the Division of Traffic. This layout sheet should show all ramps, lane widths, tapers, curve data, and typical sections of all roadways. The layout sheet may include right-of-way widths, significant drainage structures, major utilities and access control information if contributing to the interchange geometric decisions. For Grade-Separation/Interchange Projects on interstates, the FHWA shall be involved in the decision process and the geometric layout sheet shall be submitted to them for approval.

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